

**Marine Physical
Laboratory**



of the Scripps Institution
of Oceanography
University of California,
San Diego

**Studying Shallow Water Environmental
Acoustic Fluctuations with Broadband
Measurements and Fluctuations & Invariants
in Shallow Water**

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14. ABSTRACT This report describes the research performed on behalf of the Office of Naval Research (grant # N00014-99-1-0416) on Waveguide Invariants, Fluctuations and noise, and the study of feedback noise phenomenon in shallow water. The results showed both theoretically and experimentally there was a spectral focusing when propagation paths transitioned from one type to another. Additionally, the robust presence of the invariant theory in shallow water broadband data was demonstrated experimentally.					
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"Studying Shallow Water Environmental Acoustic Fluctuations with Broadband Measurements" and 'Fluctuations & Invariants in Shallow Water"

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INTRODUCTION

The above project number covered the period from 3/1/99 through 12/31/04. Besides the listed PI's, the program specifically provided full support for research scientist Dr. Philippe Roux as well as for 4 post docs and two graduate students.

This project was concerned with Waveguide Invariants. Fluctuations and noise and the study of feedback noise phenomenon in shallow water.

OBJECTIVES

- 1) To theoretically and experimentally study invariants in shallow water and search for their robust applications to shallow water acoustics.
- 2) To hold a workshop on invariants and interference phenomenon and publish the proceedings.
- 3) To study the impact on interference concepts on noise, phase conjugation and feedback techniques.

SUMMARY OF RESULTS [details of results are in listed publications]

We experimentally demonstrated that invariant theory was robustly present in shallow water broadband data. Under certain circumstances, we could perform simple matched field like processing using just the invariant and no further model calculation. This research was further taken up and transitioned including to the 6.2 level.

We also demonstrated using invariant theory that the focus of a phase conjugation process can be shift in range by a simple frequency shift. This work was later applied by Aaron Thode to demonstrate that the sidelobes of a match field processor also obeyed invariant theory and that one could localize by using the sidelobes rather than the mainlobe.

Invariant theory was also used to explain fluctuations in the phase conjugation process. Experimental data were reproduced by simulations using invariants rather than full field re-calculations. We also capitalized on interference phenomenon to do inversions.

We showed both theoretically and experimentally there was a spectral focusing when propagation paths transitioned from one type to another—for example—from refracted to surface reflected. This spectral focusing resulted because the waveguide “invariant” changed sign and therefore the group speed dependence on phase speed was reversed.

We demonstrated that the noise feedback phenomenon explored by the Russian scientist A. Furduiev could be implemented with a digital signal processing scheme. Further, that the feedback resonance was diagnostic of the environment. In a laboratory experiment, the variation associated with temperature shifts was explained by Grachev’s extension to waveguide invariant theory. This work is in the Master’s Thesis of Jason Jordan.

Included in this project was the organization of Interference Conference and two article in the proceedings. The book was published which also included two articles by some of the PI’s. One article was on waveguide invariant theory applied to environmental acoustics as measure through array processing methods. The second was on the nature of the acoustic field near interference nulls (sometime called dislocations) which are most affected in a fluctuating medium.

During this period, I was invited to write an Encyclopedia article on Underwater Acoustics.

Finally, because of the total research program in propagation in shallow water, I was asked to write a magazine article on this subject for Physics Today.

We (led by P. Roux) have also just begun studying shallow water fluctuations using the equipment used over the years in our time reversal program. In particular, with 29 sources on a vertical array and an 32 element receive array there is the opportunity to study fluctuations to great resolution. The work is being piggy-backed onto existing experiment.” Hence, work is still to be published.

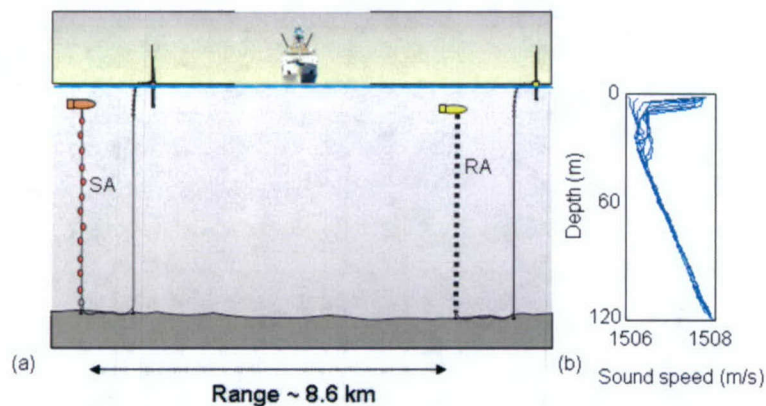


Fig.1: Schematic for experiment north of Elba Island, Italy. SRA – 29 source transducers, RA – 32 receive hydrophones, $f_c = 3.5$ kHz, and $\Delta f = 1$ kHz.

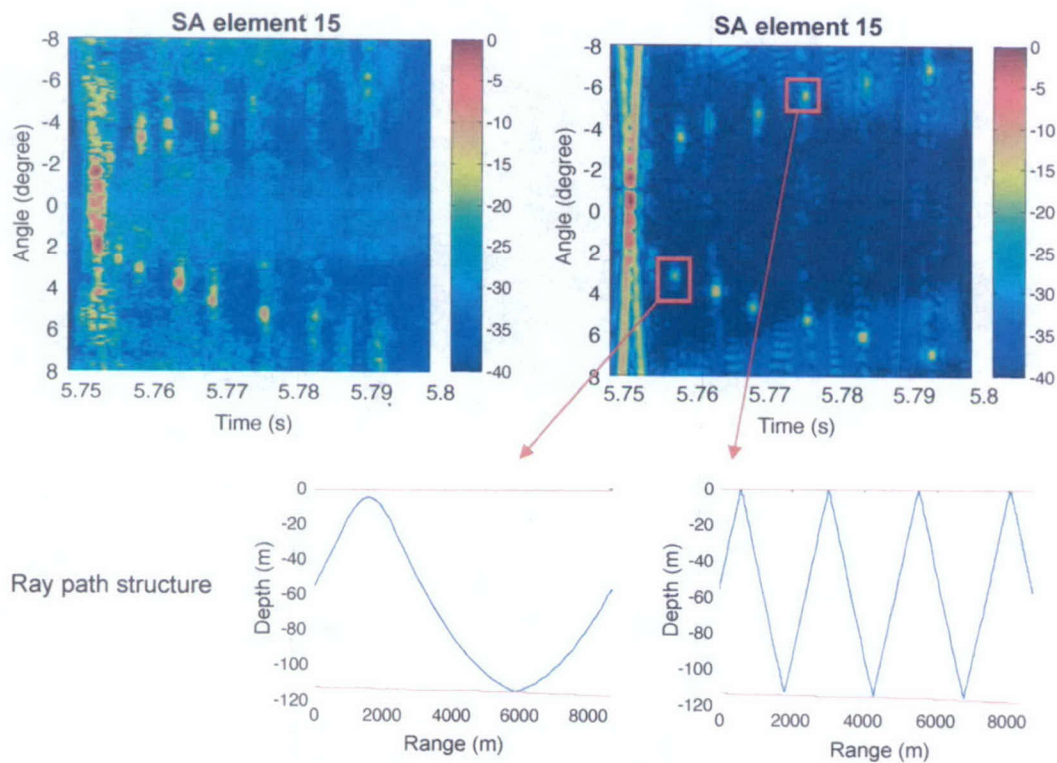


Fig.2. Comparison between data (above left) and simulation (above right) along ray path representation of selected ray arrivals (below).

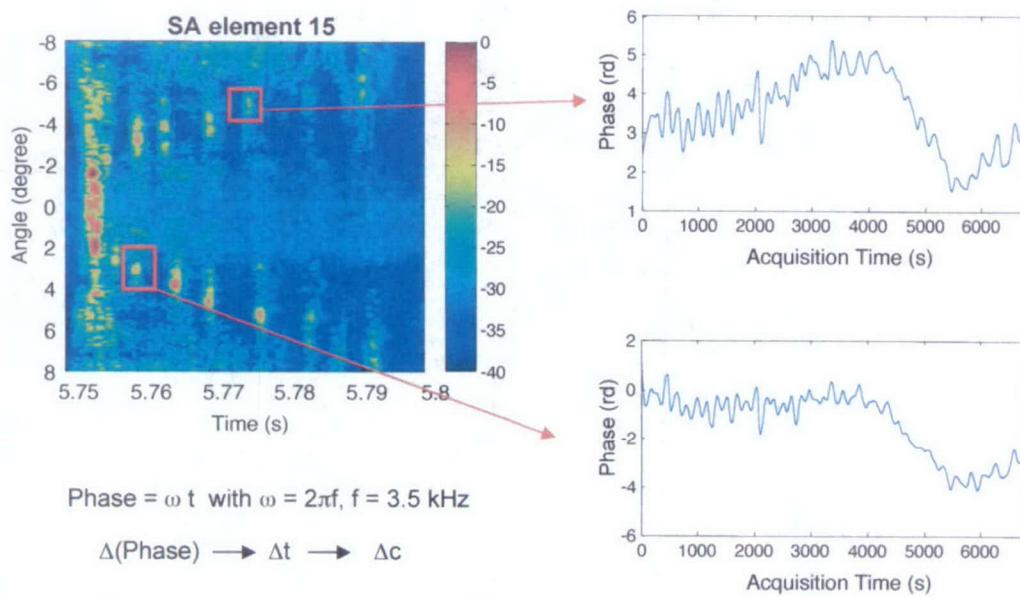


Fig. 3. Phase evolution of selected echo arrivals

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